PROPOSED

MLMIS SYSTEMS DEVELOPMENT PLAN

EXECUTIVE SUMMARY

prepared for

Minnesota Land Management Information Systems Project
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Under Sponsorship of

The Center for Urban and Regional Affairs
University of Minnesota
Minneapolis, Minnesota
Dr. John Borchert - Director

and

The Information Resources Development Fund
Department of Administration
State of Minnesota
Daniel Magraw - Chairman

by

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September 15, 1975

ACKNOWLEDGEMENTS

The author would like to thank the following people for their assistance in this three month project:

Dr. John Borchert	- University of Minnesota, Center for Urban and Regional Affairs
John Cosgrove	- University of Minnesota, Computer Center
William Craig	- University of Minnesota, Center for Urban and Regional Affairs
James Johnson	- University of Minnesota, Rapid Analysis Fiscal Tool (RAFT) Project
Leslie Maki	- Minnesota State Planning Agency
James Menter	- University of Minnesota, Minnesota Land Management Information System (MLMIS) Project
Stephen Nachtshiem	- University of Minnesota, Computer Center
George Orning	- University of Minnesota, Minnesota Land Management Information System (MLMIS) Project
Alan Robinette	- University of Minnesota, Minnesota Land Management Information System (MLMIS) Project
John Schmitt	- University of Minnesota, School of Business Administration
Donald Yaeger	- Minnesota State Planning Agency

Their cooperation, ideas and energies are appreciated.

CAVEAT-DISCLAIMION

The ideas expressed herein are those of the author and were prepared for the Minnesota Land Management Information System. This material is not to be construed as reflecting official MLMIS policies.

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I INTRODUCTION/BACKGROUND

A. Project Affiliation

The Minnesota Land Management Information System (described hereafter as MLMIS) was originally established as a research project at the University of Minnesota, under the Center for Urban and Regional Affairs (CURA) by its director Dr. John R. Borchert and his several graduate students in 1969. Due to interest generated from early results, several other groups became interested and participated in MLMIS. Within the last three years, the following groups have become involved to greater or lesser extents in the development and/or funding of MLMIS:

1. State Planning Agency (SPA), State of Minnesota
2. Department of Natural Resources (DNR), State of Minnesota
3. Department of Administration, Information Resources Development Fund (IRDF), State of Minnesota
4. Northern States Power Company, Minneapolis, Minnesota
5. Upper Great Lakes Regional Commission
6. Rockefeller Foundation
7. Arrowhead Regional Development Commission, Duluth, Minnesota
8. Legislative Committee on Minnesota Resources (formerly MRC)

Numerous other university departments, state and federal agencies and other groups have also contributed to the development of MLMIS.

B. Project Objectives

Although there are no formally written MLMIS objectives, there appear to be three objectives in the MLMIS project when it is viewed from three recognized sources.

The first objective of MLMIS may be found on the cover page of recent MLMIS publications: (1)

> "The primary goal of the project (MLMIS) is to improve the quality of land use and resource management decisions (in the state of Minnesota). The project is doing this by buidling a data bank containing information on physical resources, relative accessibility to market of these resources, and information on current land use, zoning, and ownership patterns," (and other data).

The second MLMIS objective from the viewpoint of it's originator, Dr. John Borchert has been stated at various times. The most recent and perhaps best statement of MLMIS's role was made in MLMIS Report #6, Perspectives on Minnesota Land Use - 1974.(5) Here Borchert calls for a statewide land use plan:

> "A state land use plan would be essentially the states' public judgement - expressed through its government - of the most desirable use of each type of site and location within its jurisdiction. It's purpose would be to guide the allocation of land to different interrelated uses. It would be a set of policies (and priorities) concerning land allocation."

Borchert further spells out the need for the MLMIS land planning tool:

> "Regardless of how the planning (prioritizing) and regulation of land use are structured, it is absolutely essential that there be a statewide, continuing inventory of land resources, use, value and ownership, with periodic summaries, analyses and projections."(5)

The third MLMIS objective, from the information systems analyst's point of view is to develop suitable computerized data base management tools and spatial analysis methodologies to meet these needs of resource managers and state land use planners. To the extent that these managers and planners need land related information in a meaningful format (summaries, analysis, and projections), MLMIS is attempting to collect, analyze, and present land related information as opposed to unprocessed data.[1]

Thus, the difficult technical objective of MLMIS is to translate raw data from various federal, university, state, local, and private sources into meaningful spatial, tabular and statistical information for use in short and long range land resource decision making.

The above three objectives are not necessarily complementary. The first objective is aimed at aiding resource - operational management decisions which are usually specific in nature and localized in geographic scope. The second objective of developing broad planning priorities with "periodic summaries, analysis and projections" is more theoretical in nature and statewide in geographic scope. The third objective of systems development focuses on effeciencies of the tool, rather than application of the output. In some instances these three related objectives may be in conflict. An understanding of the overlaps and potential conflicts in these three objectives (and their implications) is essential to understanding the need for this report.

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1 Inherent in this discussion are two definitions:

DATA - Unprocessed and unorganized facts, or digits, or records.

INFORMATION - Data which has been analyzed or processed to a meaningful format for some human decision.

C. Summary of MLMIS Developments to Date

The MLMIS project has accomplished many difficult tasks in its short existence; these visible products fall into six fields:

1. Development of a statewide 40-acre based land use map and survey in 1969.
2. Gathering, encoding and editing to various degrees, 16 land related variables by 40-acre parcels. These variables form the present MLMIS data base.
3. Development of a series of computer programs to process and map the MLMIS data base, including a CRT data entry system and a cellular mapping program, termed EPPL.
4. Publication of technical reports documenting the MLMIS computer software.
5. Publication of a series of geographical and land use research reports and studies analyzing various state and regional "hot spots". (Minnesota Lakeshore Study, Taconite mining, St. Croix Scenic River, Washington County Landfill, etc.) These projects utilized the MLMIS computer software and data base to varying extents.
6. Training of some 35 Geography and 15 Landscape Architecture students to use the MLMIS system, its products and analytic functions for land resource management problems. Many of these students have later taken positions with federal, state, regional, local or private agencies, where their jobs were extentions of their MLMIS experiences.

D. Reason for this Study - Statement of the PROBLEM

Based on the questions of two sponsoring agencies, including IRDF and SPA, this study was undertaken. Several questions have been raised regarding MLMIS's progress.[16, 32] These concerns focused on the need for:

1. A coordinated plan for the ultimate development of a "production" mode MLMIS. A production mode software package (one which produces well documented, consistent and timely results) presently does not exist.
2. Concentration of MLMIS efforts on the "big picture of systems development" as opposed to diversion of MLMIS resources to many unrelated special studies.
3. Speed up system "throughput capabilities" (data encoding updating and mapping) so that statewide "land use priority" maps can be produced at an early date in this biennium.

Due to these concerns CURA arranged for a study (to take a "fresh look" at MLMIS). The objectives of this study were to:

1. Evaluate existing MLMIS resources, capabilities and user demand.
2. Develop MLMIS long-range systems objectives.
3. Recommend a coordinated MLMIS systems development plan.
4. Recommend a 1975-76 MLMIS Systems Work Program and budget.

Chapters III, IV, V, VI, and VII of this report address these study objectives directly. These chapters present a set of comprehensive MLMIS goals and realistic work program elements to achieve these objectives.

II EXISTING GEOGRAPHIC INFORMATION SYSTEMS

Minnesota is not the only state that is struggling to develop a comprehensive land use information system. The states of Florida, [11] Illinois, [14] New Jersey, [20] Ohio, [8] New Mexico, [23] and New York among others, have investigated and performed initial studies for a Land Use Information System. Several state efforts have produced viable systems, others have died due to a lack of proper political, organizational or technical focus. States that have successfully developed some form of statewide information system (including software and statewide data) are few. These agencies include New York, Hawaii, [12] the Canadian Lands Directorate, [6] Maryland, [25] Wyoming, [36] and Minnesota.[19,37,38]

The system objectives, users, available resources, methods of implementation and successes of each of these systems vary greatly. It is not the objective of this report to produce a lengthy analysis of these systems, however, a summary table of five of these systems is included in Figure 1. More lengthly generalized analyses of state systems and methodologies can be found in the papers of Dangermond, [10] IRIS, [14] Salmen, [34] Caukins, [7] and Tomlinson. [44] Refer to the documentation of the Canadian Geographic Information System, [6] the Hawaii Statewide Land Use Data Bank, [12] and the Wyoming System [36] for specific descriptions of these individual systems.

Even without a comprehensive analysis of these different systems, several key characteristics of successful systems can be presented.

<u>Successful Land Use Information Systems tend to:</u>

-- maintain a practical balance between the accuracy of the original base map, the accuracy of the data encoding process, and the accuracy of automated storage and result map display.

-- use the simplest automated techniques that can still accomplish the intended resource analysis objectives at an economic level.

-- maintain or <u>present</u> a data structure which is transparent to the user.

-- have understandable and useable users and Systems Documentation.

-- develop useable intermediate products at various points throughout systems development. Those systems that take 2-3 years of "back room technical development" without any visible product rarely succeed by any measure.

-- involve users in the development of the system from the beginning of the project.

-- interface with operational administrative data files through common data keys.

No existing land information systems score 100% on all of these criteria. However the Minnesota, Hawaii and Wyoming systems score higher than others as a result of this brief analysis.

FIGURE 1

SUMMARY OF LAND INFORMATION SYSTEM CHARACTERISTICS

ORGANIZATION	SOFTWARE CHARACTERISTICS	OUTPUT	GEOCODING METHODS
Canadian Lands Directorate	Custom designed IBM 360/370 oriented PL-1 and assembly language programs. 3 subsystem manipulate polygon files 1=Input, 2=Editing-Reduction, 3=Map Analysis-Retrieval	Drum of FLAT Bed Plotter Maps (Details unknown)	Polygon digitizing using UTM coordinates
Hawaii Department of Planning and Economic Development	Tabular, non-geographic oriented processing routines. **Technical Specifications Unknown**	Detailed land parcel tabular listings, summary totals and frequency counts	No geographic reference except county, and parcel number
Maryland Department of State Planning	Collection of single purpose programs in FORTRAN, IBM assembly language (BAL) including AUTOMAP-II, MAPMERGE, GRIPS, GRIDS, Composite Mapping/Modeling Routines	91.2 acre cellular grid line printer maps plus Calcomp polygon plots	Dual System 1) Polygon digitizing (automated) using State Plane coordinates 2) Manual encoding to 91.2 acre cells using overlays
Wyoming Land Use Commission	Composite Mapping System-I (CMS-I) CDC oriented FORTRAN package, with FORTRAN and COMPASS routines to simulate CMS-II functions	640 acre cellular line printer maps (grey tone) at 1:500,000 scale with accompanying frequency counts	Manual encoding of standard 1:500,000 basemap data to 640 acre cells
Minnesota Center for Urban and Regional Affairs	Collection of 17 single purpose file management FORTRAN and COMPASS routines on CDC 3200, and other FORTRAN routines on CDC 6600 for data analysis and mapping	40 acre line printer maps, electrostatic dot plots and Dicomed color maps	Two Step Process 1) Manual encoding to 40 acre cells within township 2) Cathode Ray Tube (CRT) on-line entry to encoding to township

FIGURE 1

SUMMARY OF LAND INFORMATION SYSTEM CHARACTERISTICS

(Continued)

ORGANIZATION	BASIC STORAGE UNIT	VARIABLES ENCODED INTO AUTOMATED SYSTEM
Canadian Lands Directorate	Polygon Face	- Capability of land for agriculture - Capability of land for forestry - Capability of land for recreation - Capability of land for wildlife - Watershed boundaries - Land Use
Hawaii Department of Planning and Economic Development	Tax Parcel	- Soil types - Census tract - socio-economics - Tax map keys - State land use - Planned land use - County zoning - Land area - Land ownership - Major owners - # of structures - # of residences - Occupancy status - Structural conditions - Assessed valuation
Maryland Department of State Planning	91.2 Acre Grid Cell (State Plane Coordinate Based)	- County number - Surface water quality - Engineering geology - Transportation facilities - Ownership - Mineral resources - Sewer & water districts - Vegetation - Soils - Natural features - Slope - Watersheds - Electoral dist. - Historic sites - Land use
Wyoming Land Use Commission	640 Acre Grid Cell	- Land ownership - Mineral extractive activities - Fuel production & transportation - County number - Power production & transportation - Urban development - Forestry - Agriculture - Outdoor recreation - Wilderness - Surface water - Ground water - Wildlife/Big Game - Transportation
Minnesota Center for Urban and Regional Affairs	40 Acre Parcel	- County number - Minor Civil Division - School district - Type of public ownership - Public acquisition type - DNR highest recommended use (State lands only) - Recommended disposition, management status (State lands only) - County zoning - Bedrock geology - Mineral potential - Cu/Ni leases - Soil landscape units - Land use - Forest cover - Water orientation - Highway orientation

III MLMIS USER INVENTORY AND PROSPECTS

A. Sample Design and Rationale

A user survey was undertaken as a part of this study to obtain an objective view of MLMIS from its multiple users. Questionnaires were designed and distributed, and interviews held with Federal, State, and County agency representatives plus private firms as listed in Figures 2 and 3. The users personally interviewed, represented varied positions within these organizations (5 top administrators, 17 resource program analysts, and 5 computer/technical specialists). The geographical coverage area of the agencies surveyed ranged from a single county to a multi-state, federal region. Thus a variety of levels of geographical detail would be required by this group. All of the representatives interviewed had some familiarity with MLMIS, its products, process and background. This list of existing and potential users (see Figure 2) was compiled from past MLMIS project cooperating agencies, known leaders in the field of environmental or urban information systems, references from MLMIS staff, and consultants. This sample design was utilized based on the following practical constraints:

1. Limited time and no travel dollars were available for such a survey.
2. Potential users who had no familiarity with MLMIS would require extended semi-technical orientation session before they could evaluate MLMIS's practicability for their use. Time and staff were not available for such orientation, so a more limited group of familiar users was chosen.

FIGURE 2

QUESTIONNAIRE AND INTERVIEW PARTICIPANTS IN MLMIS USER SURVEY

Federal Agencies

Edward Bruns, Maynard Scilley	U. S. Soils Conservation Service
Edward Crozier	U. S. Department of Interior Sports, Fishery and Wildlife
James Forsyth, William Pearson	U. S. Army Corps of Engineers

University of Minnesota

Dr. John Borchert	Center for Urban and Regional Affairs
Alan Freeman	Law School
Dr. John Hoyt	Minnesota Analysis & Planning System (MAPS)
James Johnson	Rapid Analysis Fiscal Tool (RAFT)
Roy Mead, Dr. Merle Meyer	School of Forestry
Stephen Nachtsheim	Computer Center
Alan Robinette	Landscape Architecture
Dr. Richard Rust	Soil Science Department

State Agencies

Thomas Balcom, John Poate	Department of Natural Resources Bureau of Planning
Dr. Lawrence Foote, Herman Juffer	Minnesota Highway Department Environmental Planning Section
Eugene Gere, John Winter	Department of Natural Resouces Engineering Section
Jerry Heil	State Planning Agency Office of Local Affairs
Yo Jouseau, Charles Kenow, Thomas Rulland	State Planning Agency Environmental Program Activities
Leslie Maki, John Mohr	State Planning Agency Environmental Planning
Kenneth Pekarek	State Planning Agency Power Plan Siting
Steven Reckers, Roger Williams	State Planning Agency Coastal Zone Management
Dale Trippler	Minnesota Pollution Control Agency

Regional, County, and Local Groups

George Brophy	Region 9 Development Commission
John Chapuran, Ralph Keyes	Minnesota Association of Counties
Neil Gustafson	Upper Midwest Regional Council
Roy Larson	Metropolitan Council
Jack Olson	West Central Regional Development Commission
William Schwab, Stephen Thompson	Washington County Planning
Joseph Stinchfield	Northern States Power Company

FIGURE 3

MLMIS USER SURVEY PARTICIPANTS

BY AGENCY TYPE

	State Agencies	Federal Agencies	University Departments	Regional Local Private	Total
Questionnaires Sent Out	13	5	9	9	36
Questionnaires Returned	9	5	8	6	28
Personal Interviews Held	11	4	8	4	27
Telephone Interviews Held	1	0	1	2	4
Total Interviews	12	4	9	6	31

D. Survey Results

As a result of the 28 user questionnaires returned and the 27 interviews, a series of conclusions can be made regarding the MLMIS "user market". It is not to be assumed that this was a marketing survey from a profit making viewpoint. However, the techniques and approach of corporate market analysis could well be applied to this and other non-profit services.

The "user market" for the presently available 40 acre MLMIS products include the planning branches of: 1) the federal land management agencies (B.L.M., U.S.F.S., U.S.G.S., U.S. Corps, etc.), 2) the several state natural resource managing and regulatory agencies, 3) the 13 Minnesota regional development commissions, 4) large public utilities, and to a limited extent 5) individual counties.

Given this general user market, the MLMIS survey revealed the following market conditions:

1. A large portion of the users surveyed (23 out of 28) were non-computer programmers - either Administrators or Resource Program Managers (see Figure 4). This factor determined to a great extent the type of user-machine interface required for a successful system. This interface will either have to be supported by a well documented input language processor or a suitable staff of MLMIS analysts.
2. 18 of 28 users responded positively to using MLMIS products and processes, with only 3 agencies responding negatively to using such a system. (see figure 4). The agencies that did respond negatively were heavily involved in their own computer data processing.

3. Many users felt that the 40 acre MLMIS data was valid only as an academic research tool, statewide growth analysis tool, statewide land "priority" analysis tool, and common data base for state and regional agencies. To be useful for detailed site specific planning problems, users wanted 2 1/2 acre accuracy (see tabulation of Question IV, Figure 4).

4. Several projects were outlined which would make use of a 40 acre cellular system if it were available statewide. These projects included:

   a. DNR land classification system

   b. DNR State Comprehensive Outdoor Recreation Plan (SCORP)

   c. Environmental Quality Council's Power Plant Siting team

   d. Northern States Power Company, Power Plant Siting analysis

   e. Environmental Quality Council's "Rough Cut" Critical Areas Identification Project

   f. MLMIS Research Section, CURA, and SPA's Land Priority Analysis

   g. Region 9 Comprehensive Planning Project

5. Other projects were identified which would make use of a 2 1/2 acre cellular system if it were available within a nested framework of 40 acre cells for "macro to micro zoom analysis" of specific sites. These projects included:

   a. Great River Environmental Action Team (GREAT) analysis sponsored by several federal agencies.

   b. Washington County Parks and Public facility site planning.

   c. State Planning Agency, Coastal Zone Management Analysis of Lake Superior.

d. Minnesota Pollution Control Agency, water quality - land use interaction studies.

e. U.S. Department of Interior Sports, Fisher, and Wildlife Game Refuge and Parks planning.

f. Minnesota Highway Department Corridor Environmental Studies.

g. D.N.R. taconite siting and reclaimation studies.

E. Summary of User Needs

The survey showed that there is a great demand for two inter-related types of MLMIS products. A 40 acre statewide system and a localized 2 1/2 acre system to be used on selected detailed site studies. To be acceptable the 40 acre system must be:

-- well documented with users manuals, systems manuals and examples

-- statewide in coverage

-- operational in a "production mode" sense

-- easily accessible to users

-- reasonably inexpensive and have 1-3 day map turnaround

-- capable of interfacing with UTM or State Plane geocodes.

To be acceptable the 2 1/2 acre system must be:

-- capable of nesting within the statewide 40 acre cell system (the 2 1/2 acre system may never be complete for the state, but only in the 5-15% of the state which has site specific resource management problems).

-- all of the 40 acre criteria above.

IV ANALYSIS OF THE EXISTING MLMIS SYSTEM

A. Macro View

The existing MLMIS system has been developed over the past four years by several groups including; MLMIS staff, MLMIS consultants, and University of Minnesota students. This system has evolved to a rather complex network of stand alone computer routines and files.

This entire complex of manual and computerized steps is schematically depicted in Figure 6. Here maps, charts, or land survey source materials are manually encoded to a 40 acre cell within a PLS file organized by county, township, range, section, and 1/4, 1/4 section. Next this PLS file of 40's is translated to a grid cellular file. This translation process must take into account the irregularities of the PLS Survey, and the curvature of the earth. Once in a cellular file, rather simplistic analysis routines can manipulate, composite, and display maps as cellular matrices. The EPPL routines presently perform this cellular analysis.

Looking at MLMIS via a systems flowchart (Figure 7) reveals the next level of detail. Two distinct partitions are evident:

1. The original CDC 3200 Partition specially designed for 40 acre parcels within the PLS system.
2. The newer CYBER Partition which presently accomplishes the PLS to cellular translation, and also performs cellular map analysis and output.

The CDC 3200 Partition embodies a complex series of 17 routines. These routines accept a variety of inputs which are all keyed to PLS 40 acre parcels, and store the PLS file on an index sequential file. These

3200 routines produce listings, frequency counts and simple township MINNMAPS. A CYBER Stranger Tape can also be produced which is compatible with the CYBER Partition.

The CYBER Partition embodies a series of routines generally known as EPPL and SQUEEZE-SQORT. The SQUEEZE-SQORT routines translate 40 acre parcels to grid cells through a highly controversial process. Once in grid format, EPPL manipulates the cell data to produce composite cellular maps, electrostatic dot plots and cross tabulations. It must be understood that EPPL is an analysis tool used for any gridded data base although it has been most widely used with the MLMIS data base.

The existing MLMIS data base includes 17 variables as outlined in Figure 14. These variables have been encoded and edited to various degrees but the entire process is approximately 1/3 complete.

FIGURE 6

SCHEMATIC MLMIS

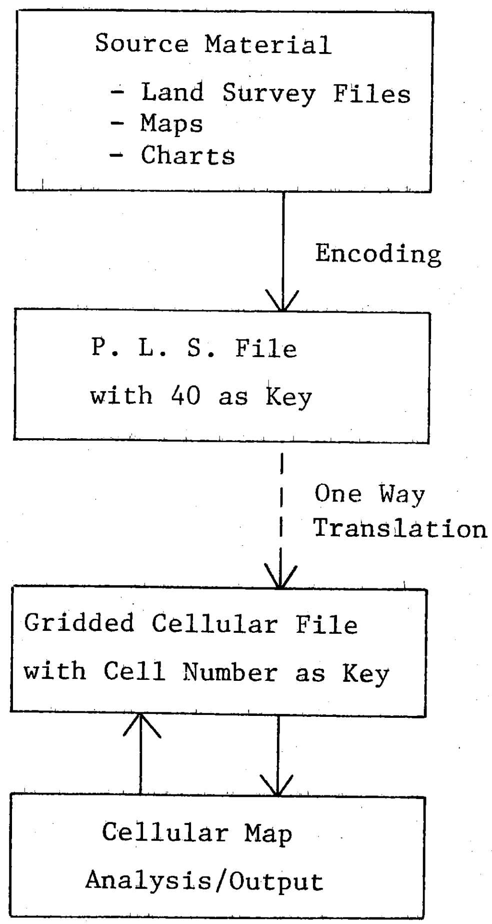
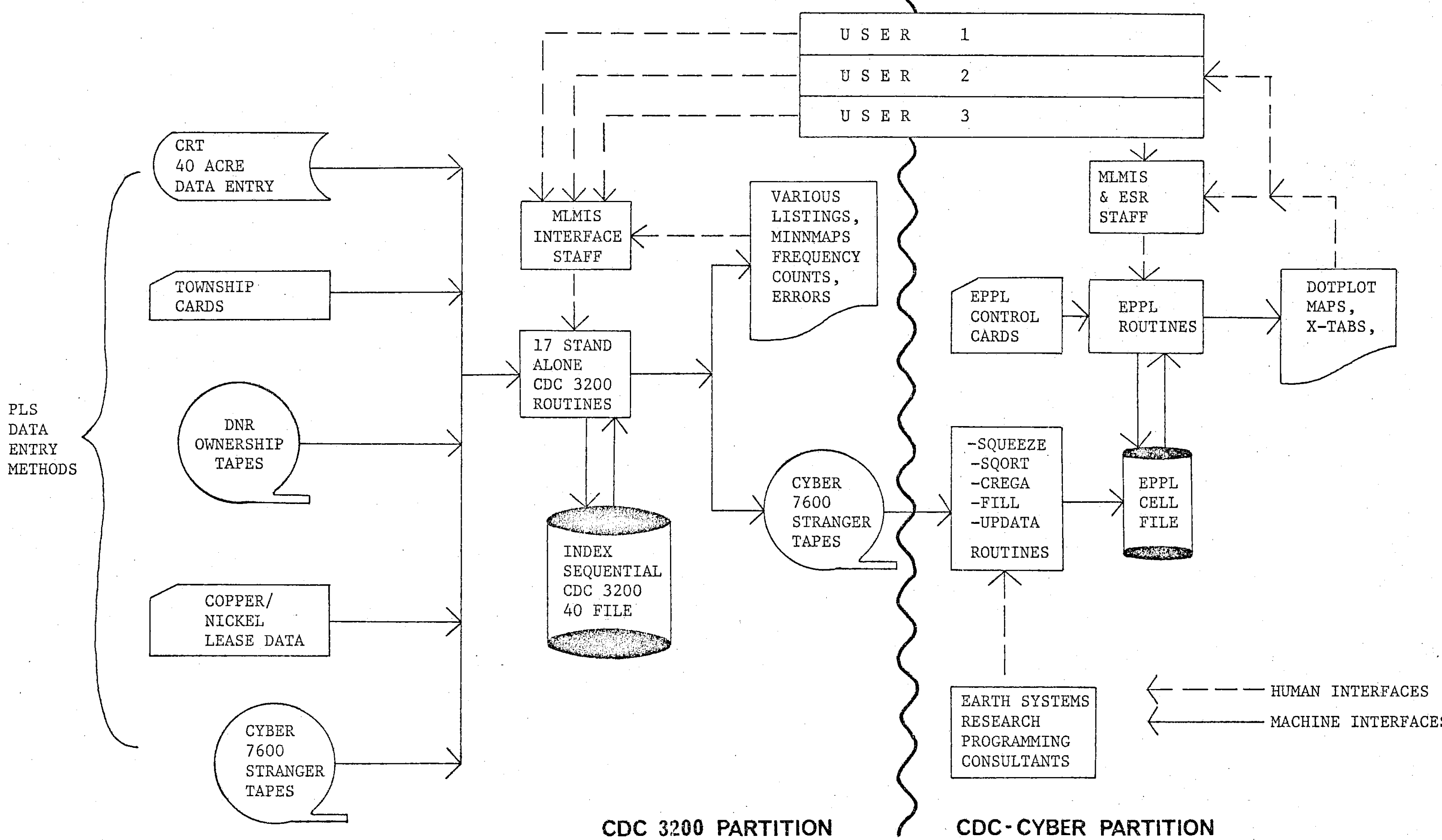


FIGURE 7

EXISTING MLMIS SYSTEM FLOWCHART



D. Existing MLMIS Data Base

Although MLMIS software could be used quite independently from the existing base, the data base should be considered as part of the system. The scarcity of better geographical data and high encoding costs preclude a major switch to different data in the near future. Thus the variables presently encoded in the MLMIS's data base (to various degrees) will probably remain the central core of data for the MLMIS 40 acre system.

This system should be thought of as a package [system data entry methods, storage structure, analysis routines, and the geographical data itself].

There are sixteen geo-physical variables available to the MLMIS system (excluding the PLS and MCD codes). These variables are in various stages of map encoding, editing and computer storage. Figure 13 describes these 40 acre variables; details regarding the legend definitions and possible values can be found in the MLMIS "V Book". (30)

As can be seen from the "V Book", each of these variables came from different agencies based on different source maps at various map scales, and projections. Further, these variables were encoded to MLMIS through different techniques. Thus the accuracy of these variables varies dramatically. These variables can be analyzed using three accuracy criteria:

1. Temporal Accuracy

Certain variables do not change over time, and the accuracy of these maps does not measurably change over time. Such

FIGURE 13

MLMIS VARIABLES AND ESTIMATED TEMPORAL AND CARTOGRAPHIC ACCURACY

Variable Number	Variable Name	Basemap Vintage	Basemap Scale	Estimated Basemap/Base Data Resolution in Acres	Estimator
V03	Minor Civil Division	1970		40	L. Salmen
V04	School District			40	L. Salmen
V05	Public Ownership Federal, State, County (except Hwy. Dept.)	1972	1:1000	10	T. Balcom
V06	Type of Acquisition	1972	1:1000	10	T. Balcom
V07	Highest Recommended Use	1972	1:1000	10	T. Balcom
V08	Recommended Disposition	1972	1:1000	10	T. Balcom
V09	State Mgmt. Unit Status	1972	1:1000	10	T. Balcom
V10	County Zoning	Varied by County 1969-1972	Varies		
V11	Bedrock Geology	1974	1:250,000	Variable 10-1200 Acres	R. Holtzman, MN Geological Survey
V12	Mineral Potential				
V13	Copper Nickel Leases				
V14	Soil Landscape Unit (and 25 associated soils suitability ratings)		1:250,000 1:250,000	160 640	R. Rust M. Scilley
V16	Land Use	1969	1:60,000	10	G. Orning
V17	Forest Cover	1962		160	US Forest Survey
V18	Water Orientation	Varied by USGS Map		40	G. Orning
V19	Highway Orientation	1973		40	

variables/maps include geological forms, soil types, etc. The accuracy of other variable maps degenerates with time because of their dynamic nature. Such variables as ownership, existing land use, county zoning, etc. change as a function of man's activities.

2. Cartographic Accuracy

   Map data can be cartographically or electronically represented only to the accuracy of the original base data, and the fractional scale of the map on which it is drafted. Thus precision digitizing of a desk size U.S. map at a scale of 1:15 million can only be accurate to one part in 15 million.

3. Data Capturing Accuracy

   Spatial data which has been automated (transferred from map to machine readable format) is only as accurate as the data transfer mechanism. Thus encoding a 7 1/2 minute quadrangle map of detailed soils types to a 640 acre grids can only show 640 acres as the smallest level of soils detail. Thus the accuracy of the encoding process limits the resulting map accuracy.

The sixteen MLMIS variables differ to a great degree in these three types of accuracy. Temporal accuracy is difficult to measure since it is a function of map vintage, and the development activities that occurred since that date. Cartographic accuracy is easier to measure. A rough estimate of the accuracy of the sixteen MLMIS variables is given in Figure 13.

Due to the limited 3200 time available for CRT data input and tedious editing procedures, only selected variables are in final EPPL format. A description of the encoding progress by variable, stage, and county is given in Figure 14. As can be seen, MCD, Land Use, Federal Public Ownership and Water Orientation are on the 3200 files, not all of these variables are edited. Region 3 has all variables encoded. All other combinations are in various stages of encoding.

FIGURE 14

MLMIS Data Status - 7/21/75

Region		1	2	3	4	5	6	7	8	9	10	11	NSP
Site				5+									5
Township		4+	4+	5+	4+	4+	4+	4+	4+	4+	4+	4+	5
MCD	**	4	4	5+	4	4	4	4	4	4	4+	4	5+
School District	*	1	1	1+	1	1	1	1	1	1	1	1	5
Public Ownership													5
State & County		3	3	5+	3	3	3	3	3	3	4	3	5
Federal		4	4	5+	4	4	4	4	4	4	4	4	5
Aquisition Type		3	3	5+	3	3	3	3	3	3	4	3	5
Highest Rec. Use		3	3	5+	3	3	3	3	3	3	4	3	5
Disposition		3	3	5+	3	3	3	3	3	3	4	3	5
Mgmt. Unit Status		3	3	5+	3	3	3	3	3	3	4	3	5
County Zoning		1	1	5+	1	1	1	1	1	1	1	1	5
Bedrock Geology		1	1	5+		1			1	1	1		
Mineral Potential				5+									
Cu/Ni Leases		3****	3****	5+									
Soil Landscape Unit													
Soil		1	1	5+	1	1	1	1	1	1	4	1	5
Geomorphic Region		1	1	5+	1	1	1	1	1	1	4	1	5
Soil Associations				5+									
Land Use		4+	4+	5+	4+	4+	4+	4+	4+	4+	4+	4+	5
Forest Cover		3***	3	5+		3***		3***					5
Water Orientation	**	4	4	5+	4	4	4	4	4	4	4+	4	5+
Highway Orientation		2	2	5+	2	2	2	2	2	2	4	2	5

Hierarchical Status

1. Maps (data) available
2. Coded in MLMIS format
3. In machine readable form
4. Entered in sequential 3200 file +edited
5. EPPL format on CYBER +edited

* Available statewide, but not considered for entry at this time

** Reliable only in Regions 3 & 10

*** Roseau, Wadena, Cass, Crow Wing, northern Pine Counties punched from Twp. forms

**** Beltrami, Lake of the Woods, Marshall punched

NSP = Pine, Chisago, Washington Counties

\+ exists on EPPL file on Itasca, Cook, and Lake Counties

E. Assessment of the Existing System

The development of the MLMIS system to date has occurred in a less than systematic manner, partially due to the many user oriented special studies which caused its creation.

The system is operational within small areas, with extensive systems programming support, however there are several major limitations which preclude its efficient use. We are pulling a complete cart, but the cart has square wheels!! The advantages of the system can be outlined as:

1. The system is flexible to allow multiple inputs of various files which are keyed to 40 acre PLS codes.
2. Once data is in a CYBER-EPPL packed binary format, the EPPL program is a quick and inexpensive method of map analysis with relative flexibility of analysis techniques and display options.

The major limitations of MLMIS can be grouped into four classes corresponding to the steps in Figure 6. These limitations include:

-- general systems operations limitation

-- source data encoding limitations

-- file translation limitations,

-- cellular analysis and output limitations

1. General Systems Operations Limitations

This group of limitations is concerned with the overall operations of MLMIS. These problems are perhaps less severe than others. They include:

a. There is no overall system development plan, statement of technical goals, or overall systems documentation. This restrains a capable technician from easily learning or becoming involved with MLMIS. This report partially fills the overall systems documentation gap.

b. Two physically separate computers (CDC 3200 and CYBER 7600) are required for the MLMIS process. The availability of the CDC 3200 for data entry is quite limited. Working within this strained dual hardware environment is taxing and cumbersome to even the experienced analyst or programmer.

c. An exhorbitant amount of skilled analyst time is needed to operate the system due to severe technical bottlenecks.

d. The existing version of EPPL is proprietary to Earth Systems Research Corporation and thus precludes its modification or enhancement by MLMIS staff. The next version of EPPL-4 will be in the public domain, but its capabilities are still undefined given present contractual arrangements.

2. Source Data Encoding Limitations

This more severe set of limitations deals with the encoding of source data to PLS 40 acre parcels. It is slowing up the entire MLMIS project as much as the file translation limitations below. Little has been done before this report to address these limitations:

a. There is an overall inflexibility for different types of user input. All data presently must be forced into PLS township format before entry to the system. The present encoding procedures require a two step manual process to go from source maps to township sheets to coding sheets. This clumsy process greatly slows down the encoding of many non-PLS variables such as soils, forestry land use or geology, which could be directly input as cells.

b. There is little formal concern given to the relative accuracies of map variables. This variable accuracy question if of utmost concern especially when maps are composited.

3. File Translation Limitations

These are perhaps the most severe limitations and are causing a major bottleneck in system progress. Little has been done to date to enact solutions to these interrelated problems:

a. The translation of CDC 3200 files to CYBER-EPPL files was written as a stop-gap measure and is now a serious bottleneck. The SQUEEZE, SQORT, FILL routines which perform this conversion require extensive programmer/analyst time, are costly to run (15 iterations for a single county per conversion) and produce inconsistent resultant maps on duplication. Due to the numerous runs and programmer decisions made between runs, study areas are seldom co-terminous when created a second time. Similarly adjoining or overlapping study areas will not match. This problem is depicted in the diagram of multiple and non-matching study area files in the Arrowhead region of Minnesota (see Figure 15).

b. There is a serious data base management problem in coordinating the 3200 files and duplicate EPPL files. As can be seen from Figures 7 and 11, the conversion of 3200 files to the 6600 is a one way street! The 3200 files never get updated and thus become out of date very quickly once transferred to the CYBER. Once on the CYBER, the EPPL files have several disadvantages:

    i. Updating of EPPL files via the UPDATA program is clumsy for large areas,

    ii. No file consolidation capability exists, thus there is no central EPPL file, but rather numerous overlapping study files which involve duplication of information and high storage costs!

c. The existing EPPL File has no ties to the overall statewide file of 40's. There is no co-ordinate geocode attached to 40's so that one could locate a 40 or section by UTM coordinate. This overall statewide co-ordinate framework is necessary to locate parcels at the 40 acre level or to nest 2 1/2 acre cells within their appropriate 40 acre cells.

4. Cellular Analysis and Output Limitations

This set of limitations deals with the analysis capabilities of EPPL and the University Computing Center. These problems are less serious but still affect throughput and overall MLMIS effectiveness:

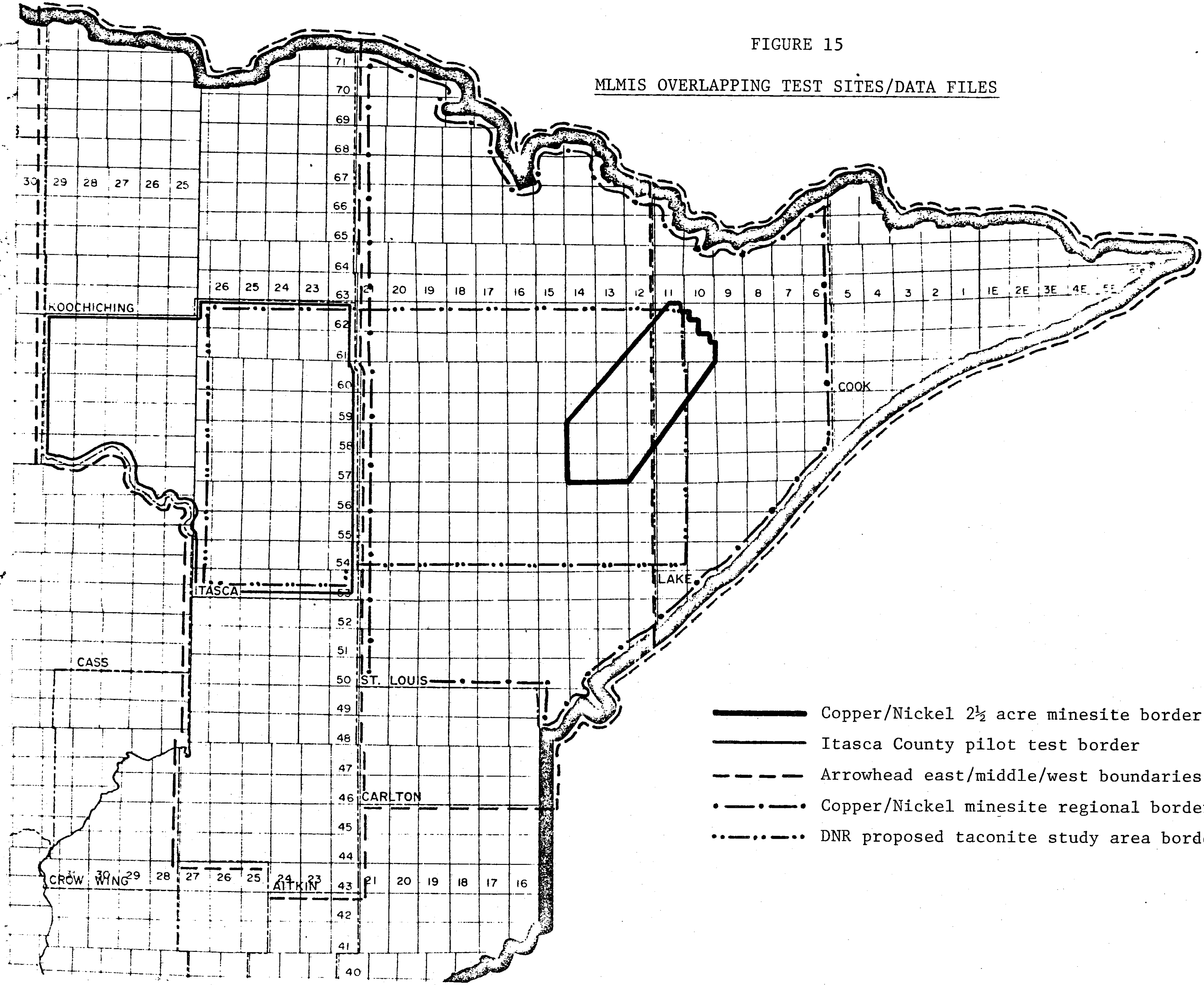
a. The present EPPL program allows only 63 variable levels on input or output and does allow for multi character codes. This makes it clumsy to encode any variable which has more than 63 single character levels (such as Township number, detailed soil types, geologic form, or socio economic data).

b. There is no production mode EPPL package since constant program developments supercede existing versions before all bugs are worked out of existing versions.

c. There are inconsistencies in the University Computing Center's STRATOS electrostatic dot plotter. Since this is the primary output device, the existing vertical distortion, variation in contrast, and even loss of entire sectors of data make the dot plotter non-reliable for use in production runs.

FIGURE 15

MLMIS OVERLAPPING TEST SITES/DATA FILES



V MLMIS OBJECTIVES

Based on the existing MLMIS system and the perceived needs of existing and potential users, the new MLMIS should strive towards achieving the following goals within the 1975-1976 Biennium.

A. <u>MLMIS Management Should Strive Towards the Following GENERAL OBJECTIVES</u>:

1. Development of a "production mode" publicly owned MLMIS System in 1976.
2. Statewide availability of all 16 MLMIS variables in an edited form for public use as soon as possible.
3. Make the system easily accessible to users either through a program language interface or a competent full time MLMIS technical interface staff.
4. Keep map <u>input accuracy</u> roughly in line with computerized <u>internal representation accuracy</u> and map <u>display accuracy</u>. The chain is only as strong as its weakest link!
5. Development of a multi-user system focused primarily towards those federal, state and regional users who would be satisfied with 40 acre resolution with the existing variables. Create "hooks" within the system so that data can be easily input at other levels (10 acres, 2 1/2 acres, UTM co-ordinates).
6. Encourage 2 1/2 acre special study projects only after the 40 acre system and 2 1/2 acre nested framework are in place.

B. <u>MLMIS Systems Group Should Strive Towards the Following Technical SYSTEMS OBJECTIVES</u>:

1. Consolidate all computer processing routines on one machine, the CYBER based on an orderly Systems Development Plan.
2. Separate the following MLMIS systems functions:
   a. data input and editing
   b. data management and updating
   c. data analysis and output
3. Maintain a simple enough "apparent data structure" so that minimal systems programmer interface is necessary to service the typical non-technical user.
4. Pilot test alternative geographical locator (geo-coding) schemes for the 40 acre file so that a one-to-one relationship exists between the 40 acre parcels and a UTM or cellular grid coordinate. Implement the most promising scheme statewide.
5. Allow flexible user input to the system through added user input interfaces including:
   a. UTM cell co-ordinates
   b. a regular cell grid (UTM based)
   c. polygon loop files (UTM based)

   Developed in that order of priority.
6. Maintain only <u>one</u> common PLS-UTM file which is updated and accessed by all active projects. Such a file would have both a UTM and PLS identifier for each entry.

7. Develop techniques to overcome the current 63 level limitations for EPPL input and output either through apparent or real data structure modifications.

8. Develop overall systems documentation starting at the top (most general) down to the more technical details of modules.

VI SYSTEMS DEVELOPMENT PLAN

This section will outline what the new MLMIS conceptually could/should look like to accomplish the objectives set forth in section IV. In section VII (MLMIS Work Program), concrete steps will be described to arrive at this conceptual picture.

A. New MLMIS Macro View

Based on the systems objectives outlined in section IV above, it becomes evident that substantial software consolidation and functional separation must be accomplished with the NEW MLMIS. An outline of this graphically would be Figure 16.

In this scheme there are four main types of data input, 1) the Public Land Survey (PLS) coded data, 2) the Census/Socio-Economic data (keyed to political subdivisions), 3) Physical data which would be directly input as cells, and 4) Digitized Polygon files. These four different inputs flow through their appropriate input interface to a common data structure. This common data structure (see figure 17) includes a UTM cell co-ordinate for each 40 acre parcel in the state. Using a single data structure and one set of files, the manager module performs all necessary data management functions in a fast and secure manner. Then, based on user analysis and study area needs, the required data file subset for the specific study area would be transfered through appropriate output interfaces to any one of several data analysis or display packages. That is a summary of the conceptual NEW MLMIS. Now for the individual component descriptions.

FIGURE 16

CONCEPTUAL NEW MLMIS

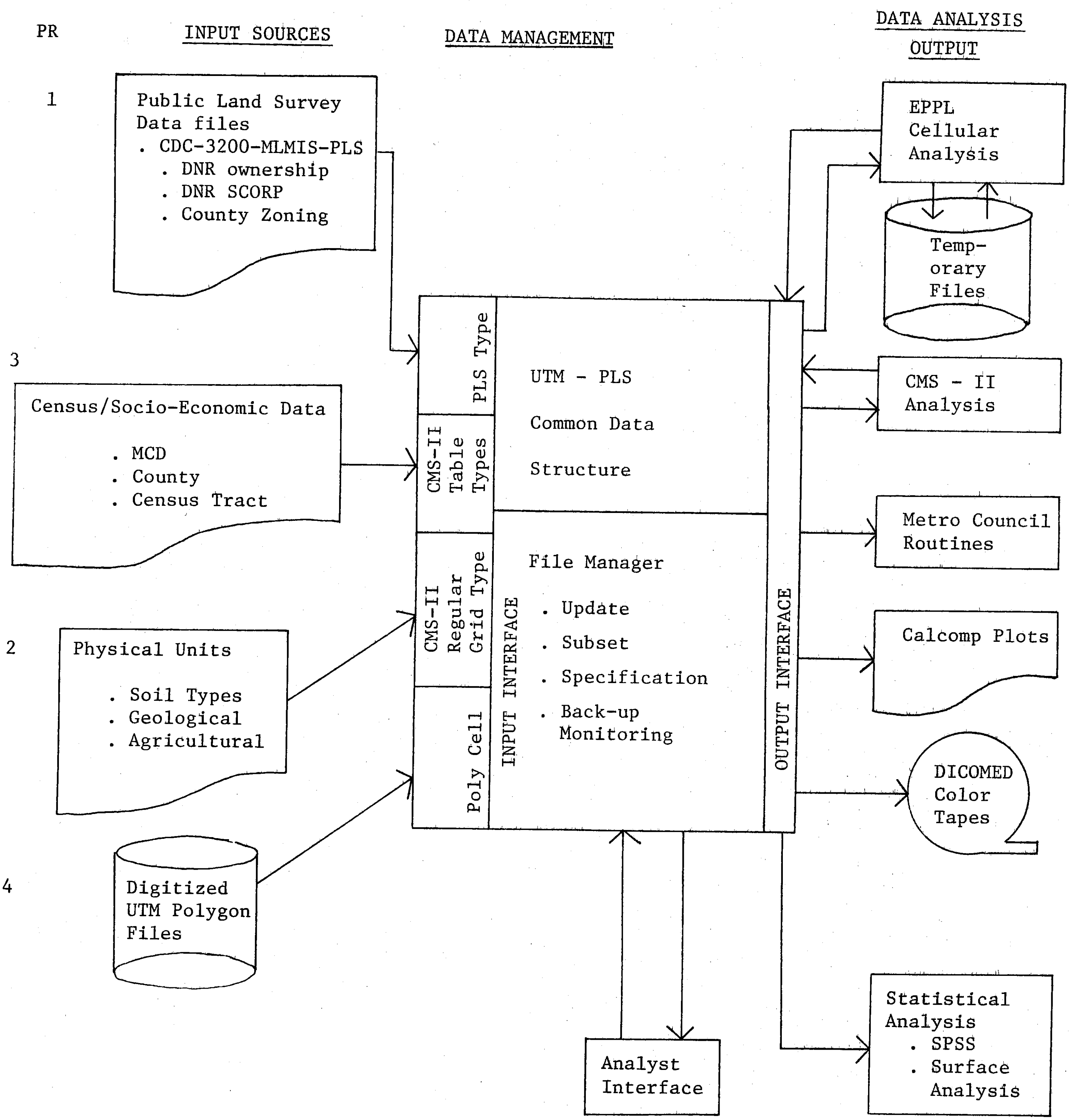
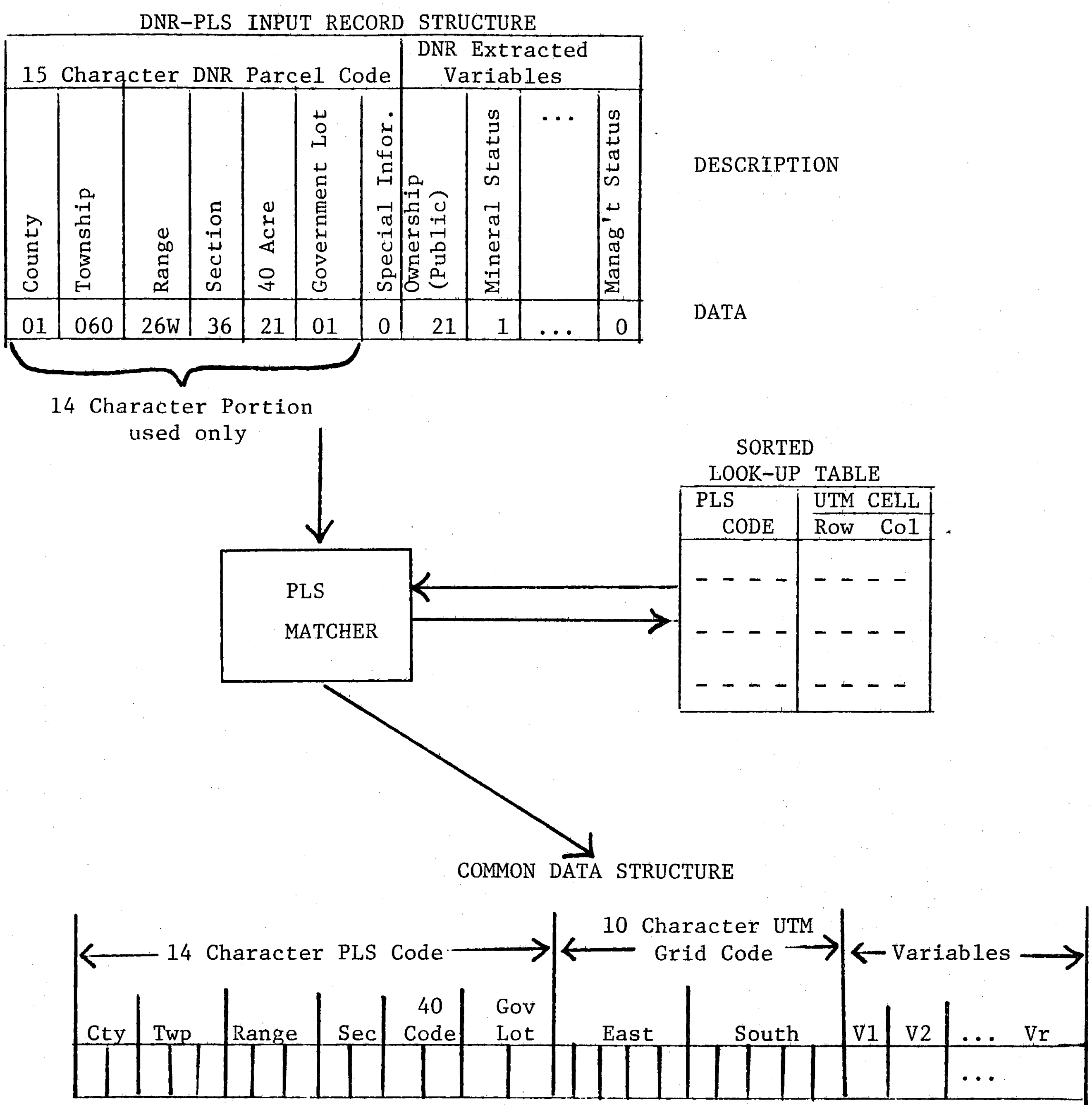


FIGURE 17

PLS INPUT INTERFACES



VII RECOMMENDED 1975-1977 MLMIS WORK PROGRAM

The 1975-1977 MLMIS Work Program stems directly from the implementation of tasks outlined in the MLMIS Development Plan (Section VI above). Several elements will be outlined in this section, including 1) needed organizational structure of the MLMIS systems component, and 2) task descriptions including time estimates, products produced, and 3) hardware resource requirements.

A. Organizational Structure of MLMIS Systems Group

To accomplish the steps outlined in section B below, a well coordinated MLMIS Systems effort is needed. The systems group will have substantial pressures put upon them to accomplish critical systems development tasks and many times may have to give systems development higher priority than day to day operational "brush-fires". To insure that systems development does proceed as scheduled the following organizational changes would be necessary:

1. Develop 3 identifiably unique funcitonal sections of MLMIS:
   a. Systems Development and Maintenance Section
   b. Geographical Research and Application Section
   c. Data Input/Output Production Section

   Each should have their own identifiable objectives, budgets, responsibilities, work programs and responsible coordinators. These three sections, however, should be coordinated under one MLMIS plan under the guidance of the MLMIS Project Director.
2. Better working environment should be provided for the entire MLMIS staff. Separated work areas for the professionals would increase work productivity and elevate the level of professionalism.

For the systems development section in particular, sufficient space is necessary to lay out large maps, spread out computer output, and provide conference space. The systems development section should be located close to a medium to high speed CYBER terminal and optimally in the environment of other systems personnel.

3. These three MLMIS sections should remain close, physically and organizationally during the upcoming rapid growth phase "system adolescent period", but these sections may become more organizationally separated as the system "matures".

4. To ensure a smooth transition to an operational agency, the systems co-ordinator and systems analyst could be hired as State Planning staff and then "loaned" for the first two years to the MLMIS project under a <u>I</u>ntergovernmental <u>P</u>ersonal <u>A</u>greement (IPA), similar to the arrangement within federal agencies.

B. Work Program Task Schedule

The following MLMIS work elements should be performed. Not necessarily in the order stated.

TASK 1 - Develop MLMIS Input and Output Interfaces

These four input interfaces and single output interface as outlined in Figure 15 should be developed, starting with the specifications laid out in this report, (section VI - B, C). Priorities for interface development should be set by management but would probably include the PLS, and physical unit interfaces first followed by the EPPL-4 output interface. Once developed, data encoding and error checking would be greatly speeded.

TASK 2 - Pilot Test Cartographic UTM Grid Assignment

This pilot test will establish the best methodology for UTM assignment; the product of this assignment is well known and can be used as a given for tasks 1 and 4. Using two pilot areas throughout Minnesota, the 7 1/2 minute quads should be tested for encoding 40's to UTM cellular co-ordinates. Development of a file of UTM co-ordinates of corners of 40 acre parcels and a PLS look-up table as shown in Figure 16 would be direct products. Alternative assignment decision rules and techniques would be assessed for accuracy of resultant cell assignment. An intermediate product would be a Pilot Test Report outlining methods used in the pilot study, resulting accuracy and implications of each approach and recommendations for a statewide cartographic assignment procedure.

This task would include the following subtasks. Initial discussions with the Minnesota Geological Survey indicates their eagerness to co-operate in this task for their own funded purposes.

Subtask 2.1 - Obtain Basemaps

Obtain copies of relevant U.S.G.S. 7 1/2 minute quadrangle maps in the small study areas selected (2 groups of 4 townships which include examples of misshaped regular sections, irregular sections, and properly shaped regular sections).

Subtask 2.2 - Draft Parcel Boundaries on Basemaps

Draft regular 40 acre parcel and government lot boundaries on the basemaps.

Subtask 2.3 - Automated Digitizing Method Trial

Using an automated digitizer if available or manual techniques if necessary, digitize the corners of each section, and corners of each parcel in irregular sections based on UTM co-ordinates. Process this digitized loop data through CMS06 to produce a UTM 400 meter cell file. Photographically, process the resultant cell map to overlay the U.S.G.S. basemap. Repeat this procedure with alternative digitizing accuracies and CMS06 cell sizes.

Subtask 2.4 - Manually Encode UTM Cells to 40's

Over the same U.S.G.S. basemap of 40's from step 2.2, lay a UTM 400 meter acetate grid. Manually encode 40's to UTM cells using the following decision rules:

- assign at least 1 UTM cell to each 40 (perhaps 2).
- keep within overall dimensions of state.
- have one or more 40 for each UTM cell.

Repeat this process with varying decision rules for allocation of UTM cells up or down, by percentage, or predominance.

Subtask 2.5 - Compare Techniques

Compare the accuracies, required times, costs and completeness of both methods. Expand this comparison to include implications for a statewide analysis.

Subtask 2.6 - Decide Better Method and Write Technical Report

Describe the step 2.5 results at a seminar with selected land use technicians. Decide upon one method to utilize statewide. This would become MLMIS official methodology and would be written up as a technical report.

TASK 3 - Perform Cartographic UTM Grid Assignment Statewide

MLMIS systems staff would implement statewide the process recommended in the pilot test (Task 2). A similar task of encoding 14 maps of 100,000 cells each = (1.4 million cells) for the state of Wyoming took 10 man months using a manual encoding process. If Task 2 recommends the automated digitizing approach, it should be substantially faster than 10 man months. Three products would result from this task:

a. a PLS look-up table which relates each 40 acre parcel to one or more UTM grid cells.

b. a PLS look-up table which would relate 2 1/2 acre parcels to UTM grid coordinates within irregular 40's only (all other 2 1/2 cell coordinates can be calculated directly.

c. a set of official MLMIS 7 1/2 minute quad base maps (scale 1:2400) showing both 40 boundaries and UTM cells.

TASK 4 - Analyze Alternative Data Management Packages

Based on the description of system needs, required Data Base Management functions, and data structures, as outlined in this report, a comparative analysis should be made of:

- System 2000 Data Base Management System, MRI Inc.
- an independently written package based on the existing CDC 3200 PLS data management routines.
- other generalized D.B.M. tools

Since it is not on the "critical path" (Figure 22) a 3-4 month time frame would be appropriate for this task. This task would not require any prerequisite and could commence as soon as possible based on the specifications of this report. This could be subcontracted out to a responsibile consultant, such as the University of Minnesota Computer Center. Such a report should present a recommended data base management system and phased implementation plan which would be carried out by MLMIS staff.

TASK 5 - Build a Simple MLMIS Data Management Package on the CYBER

The Task 4 Data Management Report should be used as the framework for this initial package implementation. Such a package should offer simple access to the common data structure. Very simple file subsetting should be offered based on County ID of a fixed number of UTM cells (120 x 120). Such a package should also handle simple illegal data code detection, file updating, file subset specification, file backup monitoring, file protection and other traditional management functions.

TASK 6 - Establish Policies for MLMIS Data Sharing

A set series of policies should be developed regarding use of MLMIS files, return of newly generated variables to the common data base, access to files, passwords, locks, etc.

TASK 7 - Consolidate all Existing MLMIS Files to the COMMON DATA BASE - FILE MAINTENANCE

The various existing versions of MLMIS files including EPPL, CYBER MODIFY, and CDC 3200 files, should be edited for overlaps, vintage of data editing, and transferred through the MLMIS input interfaces (Task 1 above) to the common data structure. This task should be undertaken only after Task 5 has been completed and initially tested.

TASK 8 - Increase Data Base Sophistication

Based on experience gained, it may be necessary to increase the sophistication of the data base manager to handle the following:

- multiple keys to the data structure
- more complex segmentations of the data file by Township, County, UTM coordinates, MCD's or other locator keys
- more limited user access to the data files, etc.

If undertaken, this should be in a phased and parallel fashion, with sufficient protection of the existing single key data base.

TASK 9 - Develop Additional Output Interfaces

Based on experience gained from existing users, needed output interfaces should be developed. Many output interfaces may be able to be developed and maintained by the application programmer. Thus this task is not imminently important.

TASK 10 - Document the System Thoroughly

As an ongoing assignment, the system should be documented in five areas:

a. Introductory Users Guide

b. Systems Overview

c. Users Reference Manual

d. Systems Reference Manual

e. Status of Data Variables Encoded

TASK 11 - Hire Appropriate Systems Staff

To perform the necessary functions of Tasks 1-10 above, a systems co-ordinator and systems analyst will be required. A staff of systems co-ordinator plus one systems analyst or senior programmer would be required immediately, later assisted by a junior programmer. The systems co-ordinator is needed to conceptualize, organize, and initially test methods and logic. His familiarity with 1) large land use information systems, 2) CDC Series 6000 computers with KRONOS, 3) other states, geographic information systems, and 4) land use planning at the state level are four important prerequisites. A systems analyst would supplement the system's co-ordinator programming skills with knowledge the CYBER's KRONOS operating system, CMS-II, EPPL, and utility routines.

TASK 12 - Encoding Data

After the Pilot UTM test is completed, encoding of soils, forestry, and any other freeform data can begin. This data would be directly encoded to 400 meter UTM cells which would later be input via the appropriate interface. This process would greatly speed up the present 2 step encoding method. It still would require a group of two full time student equivalents not spread to more than 6 students.

TASK 13 - Applications Assistance

After the major files have been consolidated, numerous requests will arise to assist individual user applications. Teaching users to subset data using the data management module, and assisting users with new study area creation using 2 1/2 acre cells, will be major tasks. These tasks can be initiated by the systmes analyst and carried out by the junior programmer. This will be an ongoing function.

The timing of these tasks are shown in Figure 21. Some tasks are not dependent on any others such as Task 1, Task 2, and Task 4. The entire set of dependencies is shown in Figure 22. Man hour allocations for the system co-ordinator and systems anslyst are shown in Figure 23. Total personal resources needed total 25½ man-months - systems coordinator, 25 man months-systems analyst, 12 man months, junior programmer, 10 man months encoding personnel, and 2 man months consulting time.

C. Hardware Resources Required

For the next two years the working hardware environment of MLMIS systems would be the CDC 3200 and CYBER 7600 moving towards exclusive use of the CYBER 7600 as soon as possible, thus phasing out the 3200.

Other MLMIS hardware requirements would be immediate access to the following equipment for day to day operations:

1. a medium to fast CYBER terminal, with a 100-300 cards/minute reader, line printer and hard wired coupler.
2. a timesharing terminal or Hazeltine CRT.
3. a Private Disc Pack on the CYBER and possibly a private. disc drive.

Secondary access is needed to the following equipment:

1. large light table for UTM grid assignment
2. large scale digitizing table for an alternative $400m^2$ UTM assignment.

Several output devices have been discussed but it is probably not within the scope of this biennium to implement new hardware devices. Work with the DICOMED color mapping hardware via compatible 9 track tapes will be tested. Some additional undetermined interface equipment could be used here. The CYBER's existing microfilm and electrostatic plotter provide sufficient capabilities for the next two years.

FIGURE 21

TIME SERIES ANALYSIS OF MLMIS TASKS

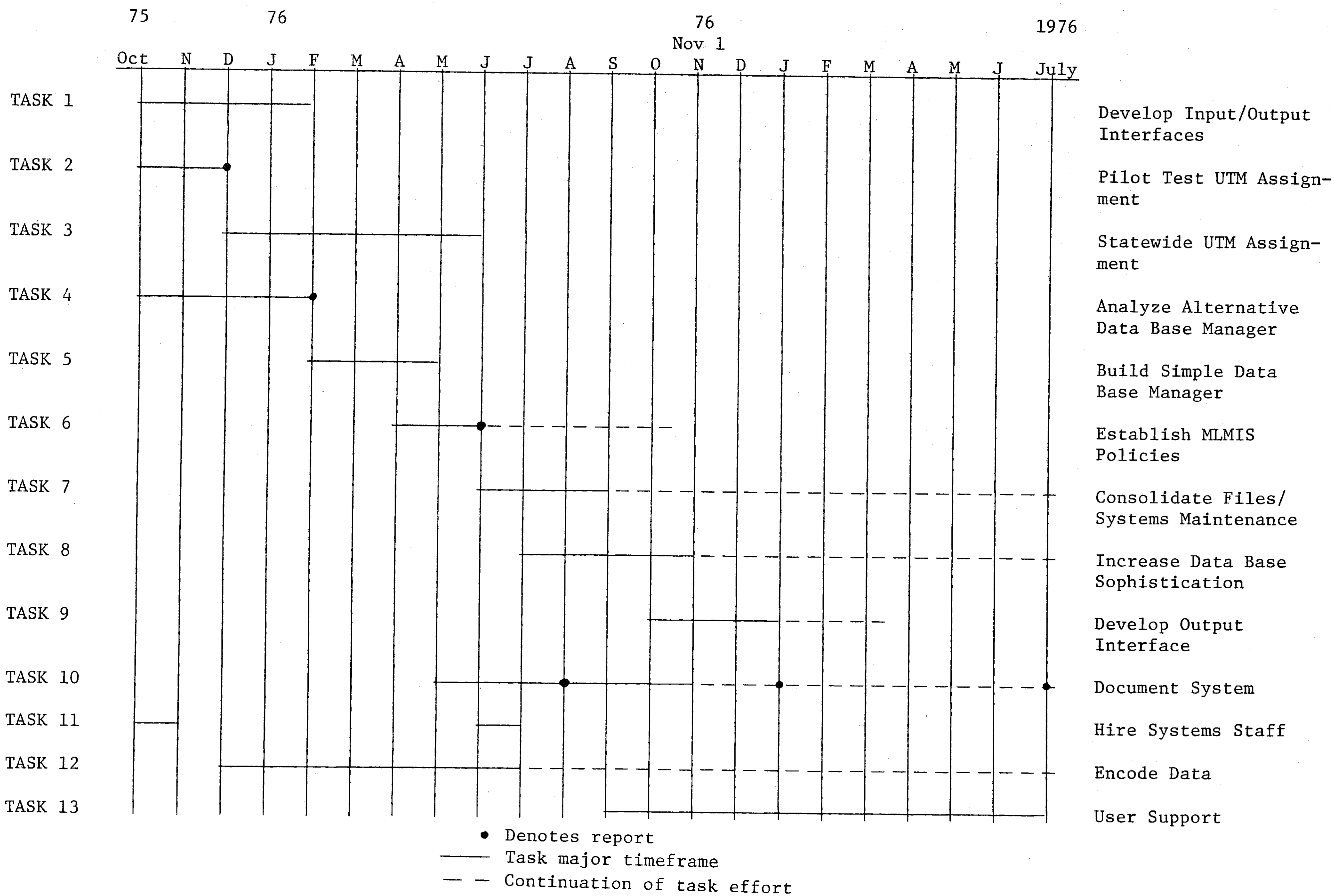


FIGURE 22

TASK TIME DEPENDENCIES

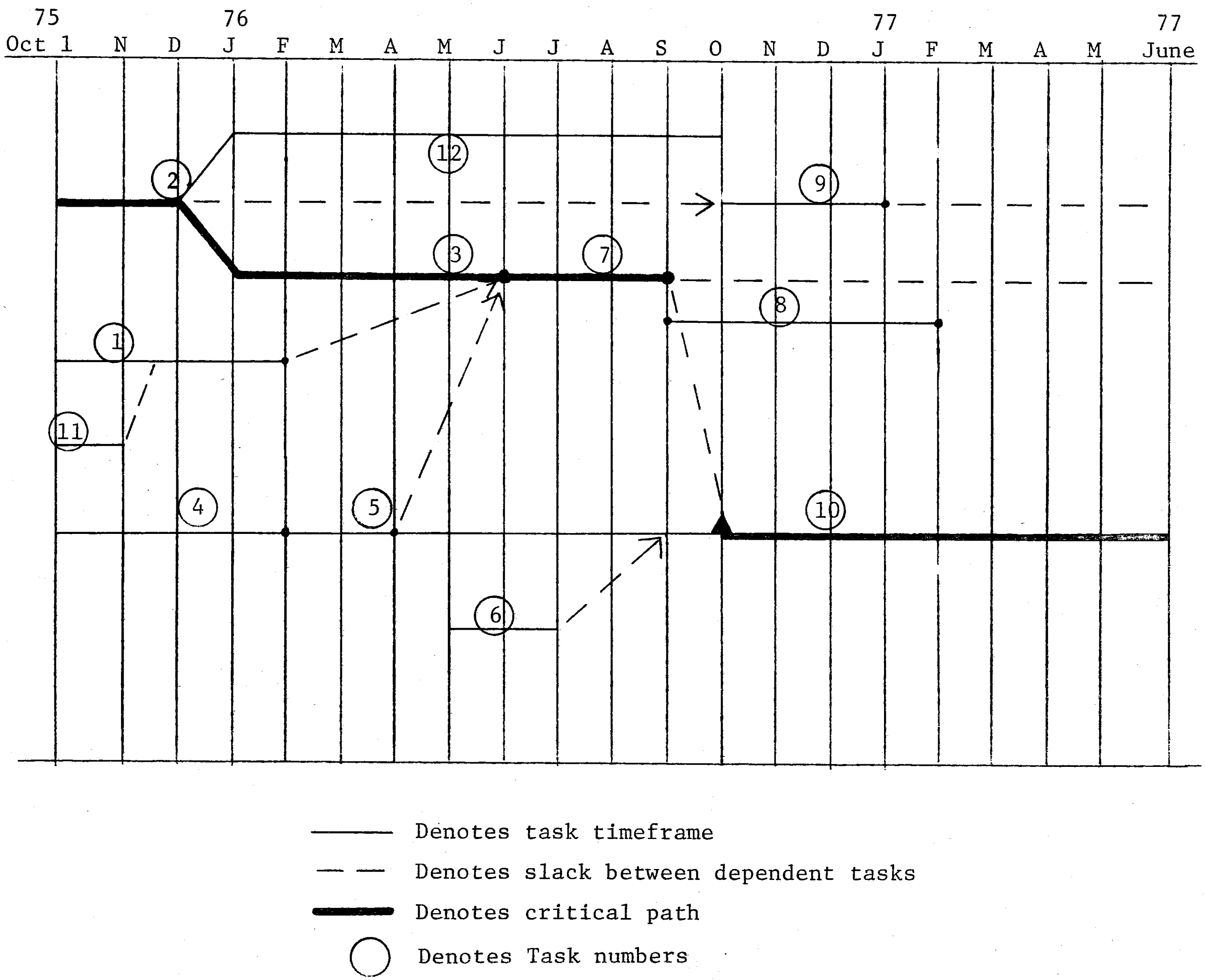


FIGURE 23

MAN MONTHS PER TASK

Task Number	Task Description	Estimated Man Months* S	P	J	E	C
1	Develop I/O Interfaces	1	2			
2	Pilot Test UTM Assignment	2	½			
3	Statewide UTM Assignment	2½	2		10	
4	Analyze Alt. Data Base Management	¼				2
5	Build Simple Data Base Management (Assuming canned D. B. Manager)	2	3			
6	Establish Data Base Policies	1				
7	Consolidate/Maintain Files	5	10			
8	Increase D. B. Mgmt. Sophistication	2	3			
9	Develop Output Interfaces	1	2			
10	Document System	6	3	2		
11	Hire Systems Staff	½				
12	Encode Data to UTM Cells (Assuming encoders time provided by other MLMIS section)	2				
13	Applications Assistances			10		
	TOTAL	25¼	25	12	10	2

* 1S = 1 man month Systems Coordinator
1P = 1 man month Systems Analyst
1C = 1 man month Consultant
1E = 1 man month Data Encoder
1J = 1 man month Junior Programmer

APPENDIX A

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